NATIONAL BUREAU OF STANDARDS *August/1968*

Technical News Bulletin

U.S. DEPARTMENT OF COMMERCE

NATIONAL BUREAU OF STANDARDS

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U.S. DEPARTMENT OF COMMERCE
C. R. Smith, Secretary

NATIONAL BUREAU OF STANDARDS
A. V. Astin, Director

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The National Bureau of Standards serves as a focal point in the Federal Government for assuring maximum application of the physical and engineering sciences to the advancement of technology in industry and commerce. For this purpose, the Bureau is organized as follows:

- The Institute for Basic Standards
- The Institute for Materials Research
- The Institute for Applied Technology
- Center for Radiation Research

The TECHNICAL NEWS BULLETIN is published to keep science and industry informed regarding the technical programs, accomplishments, and activities of NBS.

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IMPROVED FLUORESCENT LAMP CALIBRATION

An improved procedure for calibrating fluorescent lamps has been devised at the NBS Institute for Basic Standards. This work, by F. J. Studer and R. D. Saunders, makes it possible for the first time to calibrate with reasonable accuracy the lumen output of a light source of any spectral distribution by means of incandescent standards. The method is based on a comparison of flux from the lamp to be tested with that from an incandescent standard at each wavelength interval of the visible spectrum.

Using this procedure, the Bureau is now calibrating groups of fluorescent lamps of different colors to be sold to commercial standards laboratories for use as reference standards. The availability of these standards and others calibrated from them should lead to better agreement in measurements of fluorescent lamps.

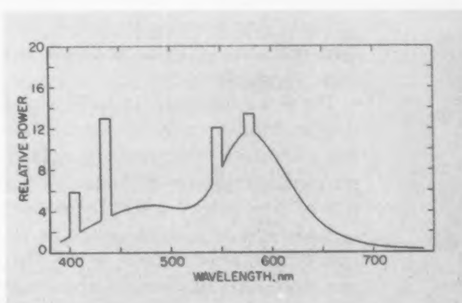
Shortly after the advent of the fluorescent lamp about 30 years ago, NBS supplied the lamp manufacturing industry with fluorescent lamp standards for use in measuring the lumen output of such lamps. The procedures followed in the calibration of those standards, however, were the customary procedures which required correcting for the spectral response of the detectors and the spectral characteristics of the integrating sphere used in the measurements. These corrections can not be made with sufficient certainty to meet the current needs for accuracy in the measurement of the lumen output of fluorescent lamps and other types of lamps that are rapidly appearing on the consumer market with spectral distributions far different from those of incandescent lamps. Thus a more accurate method has been needed for the calibration of fluorescent lamp standards.

In the new measurement procedure, flux from the fluorescent lamp at each wavelength interval of the visible spectrum is compared directly with that from an incandescent standard that has been previously calibrated for color temperature and luminous flux. Relative spectral distribution of the incandescent lamp is assumed to be the same as that of a blackbody at the same color temperature.

During a measurement, the incandescent standard and the lamp to be measured are both placed in a large integrating sphere. Flux from an open port in the large sphere is sampled by a smaller integrating sphere. A spectrometer then analyzes the flux from a window in the small sphere when the standard lamp is turned on (fluorescent lamp off), and again when the fluorescent lamp is turned on (standard lamp off). This gives a comparison at each wavelength of the flux from the lamp under measurement

continued

Above: *R. D. Saunders prepares apparatus used to compare fluorescent lamps with incandescent standards at each wavelength of the visible spectrum. Both lamps are placed in the large sphere: flux from the large sphere is sampled while each lamp is alternately operating.* Below: *Spectral power distribution curve for a fluorescent lamp was obtained by a new NBS method of lamp calibration.*



FLUORESCENT LAMP *continued*

with that of the incandescent standard.

High precision is obtained by maintaining uniform, constant operating conditions for both lamps. This means that flux from both the standard and the fluorescent lamp must be supplied to the entrance slit of the spectrometer under the same geometric conditions, and that the detecting equipment must remain stable during the time that the spectra of the two lamps are being scanned. These two objectives are realized by the use of the small integrating sphere for sampling the flux from the large sphere. In addition, an external incandescent lamp is operated at a carefully regulated current to provide a stable source of luminous flux, available to the integrating sphere for quickly monitoring the constancy of the overall response of the photocell detector and amplifier.

The spectrometer used in the NBS measurements is a double plane-grating instrument. Dispersed light from the first grating falls directly on the second without an intermediate slit. The entrance and exit slits are fixed, nearly equal in width, and have an effective spectral band pass of approximately 5 nm. Light from the exit slit of the spectrometer falls directly on the cathode of a photomultiplier tube. A picoammeter amplifies the photocell current; this amplified current then passes through a precision resistor. The voltage across this resistor is measured by a digital voltmeter, and a printout system is used to record the data on paper tape.

The data thus obtained are processed by a computer, which is programmed to convert the data to luminous flux, spectral power distribution, and chromaticity coordinates.

An important element in the accuracy of the improved measurement procedure is the speed with which the measurements can be made—2 to 3 minutes for each lamp. Very little drift in electronic and control equipment takes place in this short time. In fact, the change in the reading of the monitor during a lamp calibration is very seldom more than 0.1 percent. The uncertainty of a calibration, based on the mean of a group of six lamps, is estimated to be 0.5 percent.

VOLUNTARY STANDARDS PROCEDURES AMENDED

The U.S. Department of Commerce has amended the procedures for development of voluntary product standards. The changes reflect consideration of communications received from twenty-seven firms and associations who responded to the Department's *Federal Register* notice of August 22, 1967, inviting comments on proposed changes to the procedures.

The National Bureau of Standards, under authority and responsibility delegated to it by the Department of Commerce, is responsible for the development of voluntary Product Standards under these procedures. The Bureau's Office of Engineering Standards Services cooperates with approximately 75 trade associations in the development of these standards.

The new amendments take into account the Department's responsibilities under the Fair Packaging and Labeling Act and reflect understanding gained through the development of specific product standards since the latest revision of these procedures in December 1965.

Under the new amendments, a recommended standard may be published if there is 75 percent acceptance among producers, distributors, and consumers. In addition, the amended procedures require 70 percent acceptance within the producer segment, the distributor segment, and the consumer segment. Consideration is given in certain cases to the relative size of the producers and distributors involved.

In the event that these acceptance percentages are not satisfied, additional procedures are prescribed under which the Department may consider whether the public interest warrants publication of the standard. Under this change, general concurrence is achieved if there is 66⅔ percent acceptance among all segments of the industry and not less than 60 percent acceptance within any single segment. However, a standard meeting these criteria must first be returned to the appropriate industry committee before further action can be taken by the Department. If the committee so requests, by three-quarters vote of all eligible members, the Department will conduct a public rule-making proceeding for the purpose of determining whether publication of the standard is in the public interest.

A complete text of the new amendments appeared in the *Federal Register* of May 11, 1968. Copies of the amendments as well as copies of the amended procedures are available from the Bureau's Office of Engineering Standards Services.

PRESIDENT APPROVES FEDERAL **ADP** STANDARDS

USASCII To Extend Compatibility

On March 11, 1968, President Lyndon Johnson approved the first Federal automatic data processing standards, recommended by the NBS Center for Computer Sciences and Technology through the Secretary of Commerce.[1] Most important of these is the standard establishing the USASCII (USA Standard Code for Information Interchange) characters and code, which all computers procured by the Federal Government after July 1, 1969, must be capable of using. The USASCII consists of binary configurations in seven levels, assigned to 128 control functions and graphic characters—capital and lowercase alphabets, numerals, and separation characters. The adoption of these standards is necessary to enable computers to "talk" to one another, not only in the anticipated "checkless society," but also for the wider-based computation, control, and transaction processing systems made possible by transmission of computer data.

Also approved at the same time were standards for recording the code on magnetic tape and paper tape, both widely used in ADP and communications operations. Adopting these three standards will increase the efficiency and ease of using computer systems by extending compatibility beyond the intrasystem level.

USASCII implements the code recommended by both the International Organization for Standardization and the International Telegraph and Telephone Consultative Committee. The use of the same standard by both computer and communication systems is of particular importance because of the growing interrelationship between data processing and data transmission. Although the new standards are mandatory only for procurement by the Federal Government, their use by the Government is expected to increase voluntary acceptance of the standards within the computer industry.

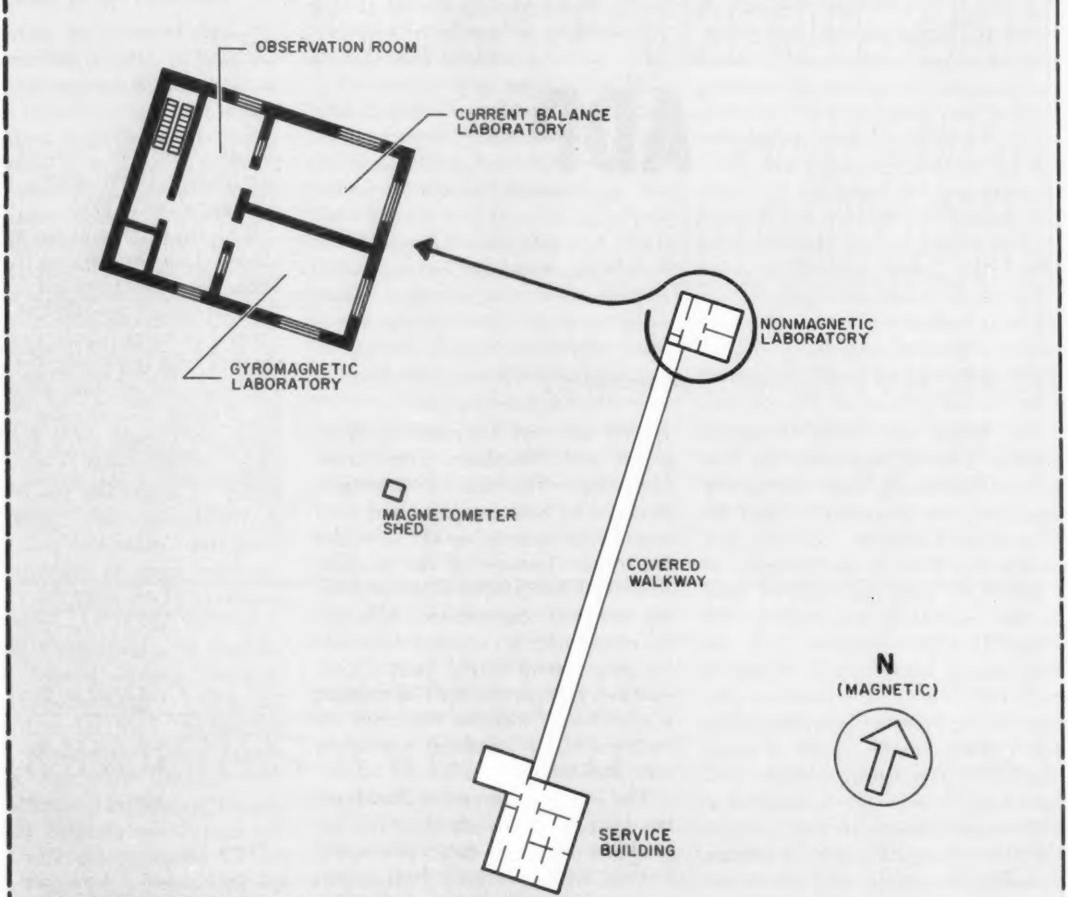
The National Bureau of Standards has long been concerned with compatibility among data processing systems and equipment, both within and outside the Federal Government. One of the goals of the Bureau's Center for Computer Sciences and Technology is to obtain better value in automatic data processing equipment for the public's dollar. Its duties include providing advisory and consulting service to Government computer activities and recommending standards for computer equipment, techniques, and languages used by the Federal Government.

USASCII development began during 1960 when the American Standards Association (now the USA Standards Institute) formed Subcommittee X3.2 to develop a coded character set for data processing and communications users. The subcommittee developed a code known as ASCII (American Standard Code for Information Interchange), which the ASA approved in 1963.

With the signing of the Brooks bill (Public Law 89–306) on October 30, 1965, the Department of Commerce, the Bureau of the Budget, and the General Services Administration were charged with improving the efficiency and economy of data processing in the Federal Government. The NBS Computer Center acted for the Secretary of Commerce in surveying industry to determine the availability of ASCII-compatible equipment. The Computer Center also polled Federal computer users to evaluate the consequences of adopting this code.

In 1965 ASCII was revised by the addition of a lowercase alphabet and increased conformity to the ISO (International Organization for Standardization) 7-bit information interchange code. Subsequently a CCITT (International Telegraph and Telephone Consultative Committee) Working Party recommended that a new CCITT telegraph alphabet based on the ISO code be developed for users needing more characters than offered by the 5-bit CCITT Alphabet No. 2. Slight changes in the CCITT and ISO codes have yielded a version acceptable to both bodies and recommended in the United States by the USA Standards Institute. Acceptance of this code for use by the Federal Government is matched by national implementation now underway in other countries, including England, Germany, France, and Japan.

[1] Copies of the standards can be obtained from the USA Standards Institute, 10 E. 40th St., New York, N.Y. 10017, at the following prices: X3.4–1967, The USA Standard Code for Information Interchange (Federal Standard No. 282), $2; X3.6–1965, American Standard Perforated Tape Code for Information Interchange (Federal Standard No. 283), $1.50; and X3.22–1967, USA Standard Recorded Magnetic Tape for Information Interchange (800 CPI, NRZI) (Federal Standard No. 284), $2.50.



Ground plan shows the conventionally constructed service building at bottom, the nonmagnetic laboratory at top, and the nonmagnetic shelter for a magnetometer to the left.

NONMAGNETIC LABORATORY OCCUPIED

A new "nonmagnetic laboratory," recently completed at the National Bureau of Standards in Gaithersburg, Md., houses apparatus for extremely precise determinations of the absolute volt and the absolute ampere. Magnetically "transparent" materials were used in the laboratory's construction so that these and other highly sensitive experiments might be performed in the undistorted magnetic field of the earth. One of six special purpose laboratories comprising phases four

and five [1] of the construction program at the Bureau's new Gaithersburg site, the nonmagnetic laboratory is now occupied by members of the staff of the NBS Absolute Electrical Measurements Section.

In recent years, NBS research that required a magnetically "clean" environment had suffered from growing interference at the Bureau's old Washington (D.C.) site. The laboratory area intended for this work was originally built (in 1914) of materials having relatively low magnetic properties. However, the magnetic properties of the once clean area were seriously impaired by subsequent modifications to nearby space and by the accumulation in neighboring laboratories of instrumentation and apparatus having iron or steel content. In addition, automobiles parked in nearby areas and moving on adjacent roadways produced intolerable magnetic disturbances. Because of its special construction, isolated location, and commitment of the neighboring ground, the new laboratory will provide a much better magnetic environment than was possible at the Bureau's old Washington site.

The Magnetic Environment

Research in which small magnetic fields are to be precisely controlled must be performed where the earth's field is uniform and free from disturbances. This requires that the laboratory structure, its furnishings, and its surroundings be free from materials that can significantly distort the local magnetic field. Iron-bearing rocks or soil, steel hardware and tools, and even steel nails in the walls, floors, and ceilings must be avoided.

With the assistance of the Coast and Geodetic Survey, the laboratory planners surveying the Gaithersburg site found an out-of-the-way spot having a fairly uniform earth's field and not close (with one exception) to any sources of disturbing magnetic fields.[2] This 600 x 600 foot square near an edge of the Bureau grounds has a horizontal magnetic gradient of approximately 3 nanoteslas (3 gammas) per meter, measured about 2 meters above ground level. This is about two orders of magnitude less than the gradient in recent years at the old laboratory in the District of Columbia.

The only source of magnetic disturbance at the new location is the enormous magnetic field from the Bureau's linear accelerator, which is located about a quarter mile away from the nonmagnetic area. Fortunately, the operation of this accelerator is not continuous and "quiet" times are available for critical work in the nonmagnetic area.

Laboratory Design

Many of the items needed in conventional laboratories cannot be permitted in the nonmagnetic laboratory. These include such commonplace things as air-conditioning machinery, typewriters, desk calculators, and even telephones. This difficulty was overcome by erecting two buildings, one a service building of conventional construction at the edge of the 600 foot square, the other a wooden laboratory building from which ferromagnetic materials were carefully excluded.

The service building houses a conventional office with telephone service, instrumentation laboratories, electrical switches and circuit breakers, a battery room, and the heating and air-conditioning equipment for laboratory temperature control. From the

continued

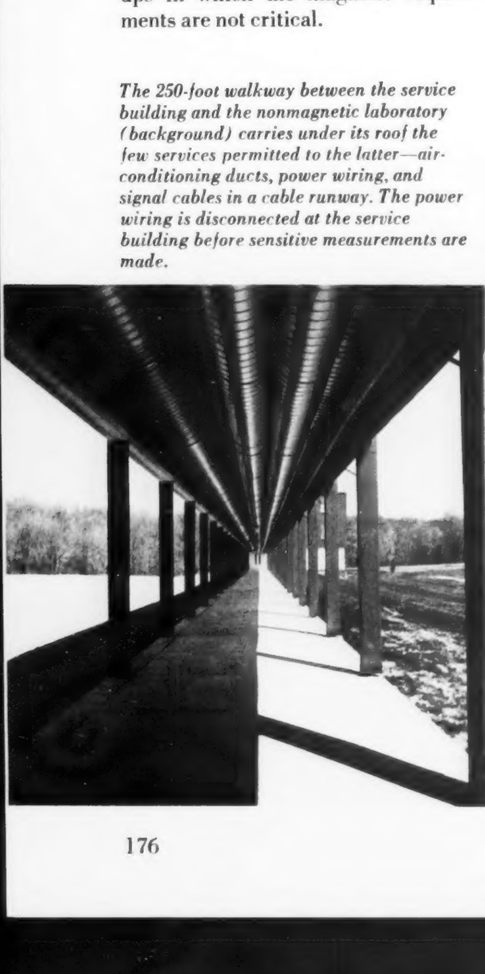
The new NBS nonmagnetic complex: the service building (left), the nonmagnetic laboratory (right), and the magnetometer shelter (beyond). The laboratory and shelter are constructed of materials "transparent" to magnetism.

LABORATORY *continued*

service building a covered walkway runs 250 feet to the nonmagnetic building. Sheltered in the roof of the walkway are ducts for conditioned and return air, wiring for electrical power, and a cable tray for signal and instrumentation lines between the buildings. No other services are supplied to the nonmagnetic building.

The minor magnetic anomalies found at ground level, resulting from iron-bearing soil and outcroppings of iron-bearing rock, forced a structural decision at the outset. Rock and soil near the nonmagnetic building could be excavated and replaced with nonmagnetic fill, or the work space could be elevated above ground level. The latter course was chosen as being less expensive; the vacant ground floor is useful as storage space for nonmagnetic items and for experimental setups in which the magnetic requirements are not critical.

The 250-foot walkway between the service building and the nonmagnetic laboratory (background) carries under its roof the few services permitted to the latter—air-conditioning ducts, power wiring, and signal cables in a cable runway. The power wiring is disconnected at the service building before sensitive measurements are made.



The floor above ground level contains an observation room and two laboratories equipped with limestone piers which rise from their own foundations and are isolated from the structure of the building. During an experiment the equipment mounted on these piers is manipulated from the observation room by means of rods passing through the wall.

A single large room above the pier rooms will be used for experimentation with calculable inductors.

A small wooden shelter set off from both the service building and the laboratory (out of range of both disturbances from equipment in the service building and the experimental fields of the laboratory) houses a magnetometer. It will be used to sense the variations in the local magnetic field in order to control a correcting current for the Helmholtz coils located in the laboratory. This arrangement compensates for the continual small natural variations in magnitude and direction of the earth's magnetic field, in order to provide stable fields in which experiments can be performed.

Construction Precautions

Obvious precautions against the presence of ferromagnetic materials in the nonmagnetic laboratory were to specify the use of aluminum alloy nails, brass or bronze hardware, plastic air ducts, aluminum vents, plastic conduits, and porcelain light-bulb receptacles. Even the electrical power receptacles had to be specified to have phosphor-bronze backing springs for the plug jaws.

It was also necessary to monitor the construction regularly and to inspect materials before use. Despite all precautions of the contractor and his workmen, the monitoring procedure occasionally disclosed that some ferromagnetic item had been inadvertently incorporated in the structure; any such item was removed before construction proceeded. The concrete for the foundations, footings, and the walkway 25 feet out from the building was made of special cement, sand, and gravel that had been tested and found to be free from magnetic impurities.

Experimentation

A uniform magnetic environment is essential for absolute determinations of the ampere and the volt in terms of the basic mechanical units. In these measurements, the absolute ampere is first determined and then used with the absolute ohm to determine the absolute volt by application of Ohm's law.

Many years ago, in conformity with international practice, the ohm was defined in terms of the resistance of a specified mercury column, and the ampere as the current that would deposit silver at a certain rate from a specified solution. But with advancing technology, it became apparent that these standards were not sufficiently reproducible. Now all three of the basic electrical units—ampere, ohm, and volt—are defined in terms of the mechanical units of length, mass, and time—the meter, kilogram, and second. These definitions are used in the difficult and time-consuming experiments required to realize the "absolute" units. The ohm is realized in terms of a calculable capacitor constructed to have a known reactance at a specified frequency. The ampere is determined in terms of the force between current-carrying coils. The volt, in turn, is realized as the product of the experimentally determined ohm and ampere.

Two types of ampere determination will be performed in the nonmagnetic building. In one pier room, a horizontal solenoid is mounted on the pier structure and a smaller, vertical solenoid is supported on a fused silica balance frame inside it. When a current is sent through the dynamometer formed by the two series solenoids, the experimenter adds weights to balance the torque produced. Knowing the distance between the knife edges of the balance, the balancing mass, and the local acceleration of gravity, the experimenter can assign the value of the current in amperes. To determine the volt, the

same current is sent through a known resistance; the voltage drop developed can be used to assign the value of the standard cells which maintain the reference unit of emf.

The current balance in the other pier room consists of a stationary coil and a movable coil suspended coaxially within it from one arm of a balance. Here, also, the current through the series-connected coils can be calculated from the coil dimensions and geometry and from the force which the current creates on the movable coil. This force is known from the action of gravity on the masses required for the balance. The value of a steady current through the coils is most accurately determined by attaining a balance, reversing the relative polarities of the coils, and determining the change in mass necessary to obtain a balance again.

Another important experiment, one making use of the precession frequency of protons in a magnetic field, is performed occasionally to detect any change in the electrical units maintained by the Bureau. A current established in terms of the NBS volt and ohm is sent through a solenoid of stable dimensions to produce a magnetic field in which the proton precession frequency is measured. It is critically important in this experiment that magnetic gradients in the observed volume be as small as possible and that the earth's magnetic field be compensated so that only the field of the current in the solenoid acts on the protons. If the precession frequency is found to be the same each time the experiment is repeated, then the units defining the solenoid current are known to be unchanged. This is because the measured frequency is dependent only on the magnetic field and on a fixed atomic constant—the proton gyromagnetic ratio. A change of less than 1 ppm in the NBS ampere can be detected in this way.

[1] **The new NBS laboratory complex**, NBS Tech. News Bull. **50**, 200–205 (Nov. 1966).
[2] Harris, F. K., **A nonmagnetic laboratory for the National Bureau of Standards**, IEEE Spectrum **3**, 85–87 (Nov. 1966).

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ANALYSIS OF MATERIAL AND STRUCTURAL FAILURES

A Service of NBS to Government Agencies

The National Bureau of Standards has announced a new procedure for assisting other Government agencies in the analysis of material and structural failures. Although NBS has provided such service for many years, the new procedure is designed to make it easier for interested agencies to make contact with the proper NBS experts. This procedure calls for agencies to refer any inquiries to a newly appointed coordinator, John A. Bennett. The NBS evaluations will be particularly valuable to agencies and field stations which do not maintain a full-time scientific staff or laboratory but which occasionally must cope with technical problems.

Research at the NBS laboratories plays a vital role in maintaining the knowledge and competence necessary to evaluate material and structural failures. The types of analyses its technical personnel and laboratory facilities are equipped to handle include: The fracture of components in machinery and transportation equipment; corrosion failures (atmospheric, marine, soil, stress, microbial); failures and service life in large metal structures; problems and failures in building construction; problems dealing with rubber and with paper; and problems in electrodeposition and metal coatings. The evaluation of the cause of failure often provides a basis for better design of structures and materials.

All questions about this service, requests for cost estimates, or requests for assistance should be directed to:

Mr. John A. Bennett
Coordinator of Material and Structural
Failure Analysis
Rm. B120, Materials Bldg.
National Bureau of Standards
Washington, D.C. 20234

CONFERENCE & PUBLICATION *Briefs*

MATERIAL FAILURES CONFERENCE

The problem of the failure of materials in service was the subject of a one-day conference held at the National Bureau of Standards in Gaithersburg, Md., on May 1, 1968. Jointly sponsored by NBS and the Washington (D.C.) chapters of the American Society for Metals and the American Society of Mechanical Engineers, the conference, entitled Must They Fail, brought together a number of engineering disciplines. It also included a luncheon address by Ralph Nader, well-known safety advocate.

Although engineers and designers have faced the problem of materials failure for centuries, the recent advances of science and technology present a new facet to the problem. Today's normal range and severity of operating conditions represent what were the extreme limits just a few years ago. This makes it essential that engineers become thoroughly educated not only in the design, fabrication, and use of materials, but also in their basic properties and their interactions with other materials and environments.

Three engineering disciplines that are primarily involved in the problem of avoiding failure in service are mechanical engineering, metallurgy, and nondestructive testing. The various viewpoints of these disciplines were expressed by six speakers commenting on considerations of design, materials science and structure, testing, fracture concepts, and nondestructive examination.

The first technical papers on the problem of service failure were related to both design and materials. C. F. Tiffany (Boeing Co.) covered the designer's approach, followed by C. M. Adams (MIT) speaking on discontinuities that develop in materials to the detriment of their properties. F. G. Tatnall completed the morning session with a review of various techniques for experimental stress analysis.

Ralph Nader relates service failures of materials to public safety.

Ralph Nader's talk on "Service Failures and Public Safety" reflected his interest in the areas of consumer products and transportation. In the future, he stated, the engineer who designs a product must heed the social, political, and economic implications of his work as well as the usual engineering considerations. Mr. Nader related this statement to the problem of ethics for the engineer, particularly with respect to the engineer's responsibilities to the corporation versus his responsibilities to the public as a professional person.

In the afternoon, E. T. Wessel (Westinghouse) and W. S. Pellini (Naval Research Laboratory) presented two views of fracture. Dr. Wessel offered his view of fracture mechanics as an engineer, while Dr. Pellini discussed the advances in analytical interpretations of engineering tests.

The techniques and criteria for designing, analyzing, testing, and selecting material having been reviewed, the remaining question was determining a material's departure from perfection. S. A. Wenk (AVCO Corp.) covered this topic in his treatment of the role of nondestructive testing.

The conference concluded with a panel discussion headed by J. Kruger and J. A. Bennett (both of NBS). In this final session Mr. Bennett stressed the significance of the effects of inhomogeneities in materials on service failure. Dr. Kruger pointed out that the environmental factor, which ultimately determines the success of the material in service, may sometimes override even some of the many important structural and design factors.

The conference was under the chairmanship of Nathan C. Promisel, executive director of the Materials Board of the National Academy of Sciences–National Academy of Engineering. Conference arrangements were handled by Harvey P. Utech (NBS) and Charles L. Staugaitis (NASA).

SYMPOSIUM ON THERMAL EXPANSION OF SOLIDS

A Symposium on Thermal Expansion of Solids, sponsored by the Westinghouse Astronuclear Laboratory and the National Bureau of Standards, will be held at the NBS Gaithersburg (Md.) facilities September 18-20, 1968. The theme of the Symposium is the measurement and analysis of this thermophysical property.

Accurate data on the thermal expansion of solids are required in many areas of research and technology. Such data are essential for the study of lattice defects and phase transitions in solids, for the theory of thermal expansion, and for reference materials used in comparison measurements of other specimens.

The program will consist of 12 invited papers and 20 contributed papers. Sessions will include the following topics: Theory of thermal expansion; structural aspects of thermal expansion; low-temperature techniques; recent measurements at low temperatures; dilatometers; optical comparators; interferometers; diffraction methods; applied temperature measurements; applied instrumentation; data compilation at the Thermophysical Properties Research Center; and reference materials and computations.

For additional program and registration information, write:

Richard K. Kirby
Rm. A221, Metrology Bldg.
National Bureau of Standards
Washington, D.C. 20234

ACM TECHNICAL SYMPOSIUM

On May 16, 1968, the National Bureau of Standards was host at its Gaithersburg (Md.) facilities to the 7th Annual Technical Symposium of the Washington, D.C., Chapter of the Association for Computing Machinery. The Symposium, held under the chairmanship of G. Richard Reed (Department of the Navy), attracted more than 625 attendees and speakers, many of them from beyond the area served by the Washington Chapter. Its introductory program and seven sessions were devoted generally to the "technology gap."

The Symposium opened with the introduction of the keynote speaker, H. R. J. Grosch, Director of the NBS Center for Computer Sciences and Technology. Dr. Grosch reminded the attendees that the computer is a tool which can be used in closing the technology gap between our expert handling of scientific and business problems, on the one hand, and the poorly defined, messy, and urgent problems of the cities and the world as a whole, on the other hand. Computer people, he said, now can spread their skills into areas like the poverty program, international cooperation, and disarmament, areas in which concern is at least as important as efficiency.

The keynote address was followed by a panel, under Carl Hammer (UNIVAC), Chairman of the D.C. Chapter, ACM, which considered the technology gap. The rest of the program was divided into seven sessions, three running concurrently during the morning and four during the afternoon. The format and content of each session was selected by one of the Chapter Special Interest Groups from areas of especial interest to the Group.

The Special Interest Group for Social Implications included a discussion of the present and future impact of computers on health care, in doing such things as performing hospital tasks, monitoring patient condition, and making diagnoses. Another paper noted the social implications of congressional use of information technology.

The session sponsored by the Special Interest Group for On-Line Computer Use reported on the utilization of remote terminals with NBS's Univac 1108, standardization activities for computer networks, the CORD time-sharing system at the NBS research facility, a time-shared data management system, and incentives and quantitative models for computer-aided instruction.

The third morning session was sponsored by the Special Interest Group for Business Data Processing. Subtopics were: tree-structured lists as a tool for data management, a list-processing extension of Fortran, uniform data element description, and a linear geographic concept for the management information system.

Several applications of a new system of computer-assisted mapping were described in an afternoon panel sponsored by the Special Interest Group for Graphics. This system resulted from a cooperative effort over a year and a half of the Coast and Geodetic Survey (of the Environmental Science Services Administration) and the IBM Corporation, resulting in a cathode ray tube device for producing aeronautical charts.

The session sponsored by the Special Interest Group on Documentation was concerned with computer project management via documentation. The elusive goal of project control was investigated from different points of view by experts on: the user, hardware, software, standards, and program management.

The private professional school and its students were discussed by a panel brought together by the Special Interest Group for Standards. A wide range of viewpoints was advanced by the panel, which included computer users, educators, and administrators. Some of these persons represented the positions of user groups—the ACM, the Systems and Procedures Association, and the Data Processing Management Association, others of associations of technical and business schools, and others of an accrediting organization. Aspects touched on included standards for enrollment, instructors, and curriculums, as well as graduate employability, job placement, and accreditization.

The Special Interest Group for Numerical Analysis sponsored a session which included papers on the solutions of the Navier-Stokes equations and fluid stability problems, the calculation of convection flows in a room, the optimization of numerical integration by use of a power series, and the empirical selection of multistep integration methods.

No *Proceedings* for this symposium is planned.

NBS MEETS WITH PITTSBURGH INDUSTRY

An all-day seminar to acquaint Pittsburgh industry with the program, facilities, and services of the National Bureau of Standards was held in that city on May 21. A group of approximately 80 research directors and technical man-

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COMPUTER-ORIENTED FIG

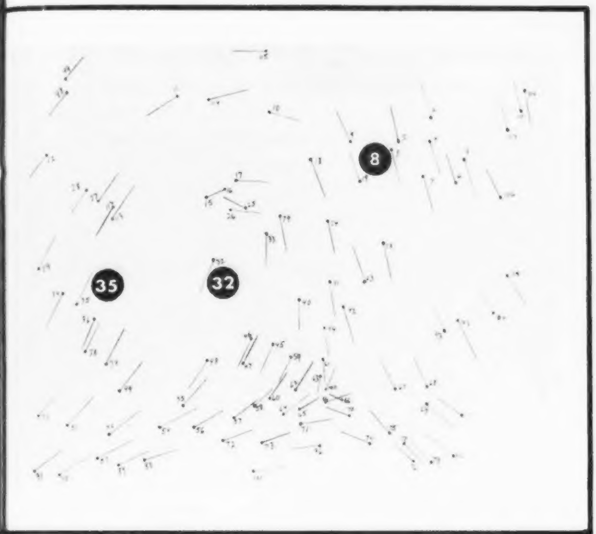
Progress Made in Automating Fingerprint Searches

Below: *John Rafferty keyboards criteria, used in selecting "constellations" of fingerprint minutiae, into the Bureau's Mobidic computer (background), which matches fingerprint impressions.*

The NBS Center for Computer Sciences and Technology has completed the first stage in developing a system for encoding fingerprint identification, in work being done for the Federal Bureau of Investigation. Joseph Wegstein, of the Computer Center, designed the procedure using a computer to produce compact descriptors based on the minutiae, or fine details, of the fingerprint impression. The system will, when completed, produce a matching "score" for each fingerprint comparison and can be used even for partial impressions. Automating even part of the fingerprint identification process will reduce the manpower required to search for matches and could speed identifications.[1]

The fact that no two fingerprints have ever been found to be identical has made them invaluable for establishing identification in law enforcement and by both military and civilian

FINGERPRINT DESCRIPTORS



Location and direction of fingerprint ridge endings and bifurcations are graphically duplicated on an overlay of the photograph (left).

government agencies. The FBI currently has over 60 million sets of fingerprint impressions in its civil file and about 17 million in its criminal file.

The use of fingerprints is impeded by the difficulty of classifying them succinctly; the Henry system, which has been in use for over 60 years, requires impressions of all ten fingers. In searching for a matching fingerprint, a hundred or so in the same Henry classification must sometimes be inspected. This work is done manually and the results of the search are not available as rapidly as might be the case with computer-stored information.

In planning the computer-aided identification system Mr. Wegstein took advantage of the uniqueness of fingerprints and used a single-fingerprint identification, which could later be expanded to a full ten-print system if desired, in order to minimize computer memory requirements and speed the search procedure. In use the system will identify the impressions that give the best match; they will then be submitted to an expert for matching. If ever a device for automatically reading minutiae from fingerprint cards is perfected, the system will offer great economies and faster service.

Minutiae

Fingerprints currently are identified, in the Henry system, by the presence of pattern characteristics (arches, loops, and whorls) and by counts of the ridges between certain features. This method is tedious and not readily adapted to a computer. On the other hand, two fingerprint impressions can be demonstrated to come from the same individual by an altogether different method.

Mr. Wegstein chose to characterize fingerprints by comparing only certain groups of minutiae from among the ridge endings, bifurcations (forks), incipient ridges, islands, and enclosures that make a fingerprint unique. Sufficient correspondences to prove that two impressions originate from the same finger can be obtained in this way even from partial prints that could not be classified by the Henry system.

This technique uses the location and orientation of just two kinds of minutiae; ridge endings and ridge bifurcations. The position and direction of each minutia are marked on a transparent overlay on a 10× enlargement of the fingerprint impression, using as a reference arbitrary x-y axes. The x and y coordinates and direction are recorded for each minutia. This is a manual stage which eventually may be performed by machine.

Constellations

The typical fingerprint contains about 80 minutiae, depending partly on how much the finger is "rolled" when the impression is taken. Each minutia is assigned in turn as a focal point, for which the computer seeks out others lying within a distance d of it and having a direction differing from the focal minutia's direction by an angle less than α. Trial focal points having at least W other minutiae in its constellation are retained if they do not duplicate others previously found. The parameters W, d, and α can be varied to make the comparison more or less selective; four to twelve constellations per impression can be expected for the values:

$W=4$, $d=20$ mm, and $\alpha=12°$.

Coordinate Transformation

At this point the computer is dealing with the location and orientation of minutiae forming the acceptable constellations. Its next step is to trans-

continued

form the coordinates of each minutia in a constellation so that the coordinates are independent of the position and angle at which the impression was made.

The computer is programmed to compute new x and y coordinates for each minutia in a constellation relative to coordinate axes centered in the constellation itself. The y axis is rotated so that it lies along the mean direction of the minutiae.

Descriptor Generation

Next, all accepted constellations are placed in a qualitative form by assigning to each constituent minutia a relative position. As one proceeds in the x direction, the y value for each minutia in a constellation is replaced by a ranking integer. The resulting string of integers constitutes the main part of the descriptor. Thus, in a four-minutiae constellation, the descriptor 2-0-3-1 would indicate that the second minutia had the smallest value of y and the third had the largest. Descriptors are further abbreviated by replacing the strings of permuted numbers by individual code numbers.

Matching Fingerprint Descriptors

The system will encode an entry for each print; the direction, coordinates, and compressed descriptors are given, as well as an identification number for that impression.

The second phase of the project involves experimentation with various methods of matching fingerprint descriptors. In one promising approach, descriptors for two impressions in the computer file are compared and a total score obtained for their similarity. High scores indicate a similarity and justify visual comparisons.

[1] Wegstein, J. H., Rafferty, J. F., and Penak, W. J., **Matching Fingerprints by Computer**, NBS Tech. Note 466 (in press): also, Wegstein, J. H., **A Computer Oriented Single-Fingerprint Identification System**, NBS Tech. Note 443 (25 cents). For sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402.

agers from Pittsburgh-area companies was given briefings by senior staff members of the Bureau and attended a luncheon discussion. The program was arranged and coordinated by Lewis E. Conman, Director, Pittsburgh Field Office of the Department of Commerce, in cooperation with George S. Gordon, Chief of the NBS Office of Industrial Services.

This seminar, the first of its kind, may serve as the prototype for a series of State and regional meetings to enable industry to take better advantage of the services offered by the National Bureau of Standards.

Shirleigh Silverman, NBS Associate Director for Academic Liaison, who acted as moderator, gave an introductory talk in which he explained the role of NBS in providing leadership and a central tie point for the National Measurement System of this country. Emphasizing the need for increased communication between industry and NBS, he gave the industry representatives a brief glimpse of the Bureau's resources, programs, and outputs. He then introduced the other speakers as representatives of some of the Bureau's key programs.

Speaking on "Future Standards for Instrumental Analysis," Bourdon F. Scribner, Chief, NBS Spectrochemical Analysis Section, reviewed the requirements for standard reference materials and discussed research that is now being done to reduce the need for large numbers of costly reference materials in the instrumental analysis of solids such as alloys and glasses. He gave examples of progress toward this goal in the fields of optical emission, x-ray fluorescence, and electron probe analysis.

Elio Passaglia, Chief, NBS Metallurgy Division, talked on "Metallurgy Research." The objective of the Bureau's work in this area is to improve understanding of the basic properties and behavior of metals and to make available reliable quantitative data on their performance. The research program consists of efforts in three main fields: (1) Mechanical properties, (2) interfacial phenomena, and (3) electrons in metals.

The luncheon session was devoted to the Bureau's Research Associate Program, a cooperative effort in research between NBS and industry. Dr. Gordon told how the program makes it possible for scientists and engineers to conduct research at NBS under the sponsorship of individual companies. He introduced two Research Associates now at NBS, Ben Justice of Corning Glass Works and Milton D. Burdick of the Porcelain Enamel Institute, who spoke briefly about their current work. Mr. Justice is using interferometric techniques to study the microinstability of glass and glass ceramics of the type that is used in making massive telescope mirrors. Mr. Burdick is working to develop tests for quality control of porcelain enamels. John G. Donelson, Director of the United States Steel Corporation Applied Research Laboratory (Monroeville, Pa.), also

Shirleigh Silverman opens the seminar held in Pittsburgh on May 21 to inform local industry of the program and services of NBS.

spoke of the advantages to an industrial firm in having its Research Associates make use of the Bureau's facilities and competence in pursuing research of mutual benefit.

The afternoon session began with a talk on "Building Research" by James R. Wright, Chief, NBS Building Research Division. Dr. Wright discussed the Bureau's role in providing a scientific and engineering basis for the development of standards of performance by public and private standards-generating organizations. Such standards make it possible to match the performance capabilities of building materials, components, and structures to the functional requirements of the user or designer with respect to strength, safety, durability, effectiveness, and economy.

"Computer Sciences and Technology" was the subject of the final talk, presented by Joseph O. Harrison, Chief, NBS Office for Information Processing Standards. Dr. Harrison discussed the activities of the NBS Center for Computer Sciences and Technology, which under Public Law 89–306 (Brooks bill) is working to improve the procurement, utilization, and management of information processing systems in the Federal Government. An important phase of this program is the development of uniform Federal standards for automatic data processing equipment, techniques, and computer languages. The Center also works closely with the USA Standards Institute to support the development of voluntary ADP standards. It should be noted that in March of this year President Johnson approved the first Federal ADP standards, which were recommended by the Center through the Secretary of Commerce (see page 173).

SCHEDULED NBS-SPONSORED CONFERENCES

Each year NBS sponsors a number of conferences covering a broad range of topics in science and technology. The conferences listed below are either sponsored or co-sponsored by NBS and will be held at the Bureau's Gaithersburg, Md., facility unless otherwise indicated. These conferences are open to all interested persons unless specifically noted. For further information, address the person indicated below in care of Special Activities Section, Rm. A600, Administration Bldg., National Bureau of Standards, Washington, D.C. 20234.

1968 Standards Laboratory Conference. Aug. 26–29. Sponsor: National Conference of Standards Laboratories (NCSL). Contact: George Goulette, University of Colorado, Boulder, Colo. 80302.

Conference on the Structural Properties of Hydroxyapatite and Related Compounds. Sept. 11–13. Contact: W. E. Brown (NBS Polymers Division).

Measurements Technology. Sept. 17–18. Cosponsor: Scientific Apparatus Makers Association. Contact: G. E. Lawrence (SAMA).

Conference on Thermal Expansion. Sept. 18–20. Cosponsor: Westinghouse Astronuclear Laboratory. Contact: R. K. Kirby (NBS Metrology Division).

Performance of Buildings—Concept and Measurement. Sept. 23–25. Contact: W. W. Walton (NBS Building Research Division).

1968 International Conference on Modern Trends in Activation Analysis. Oct. 7–11. Cosponsors: U.S. AEC; International Atomic Energy Agency; EURISOTOP. Contact: P. D. LaFleur (NBS Analytical Chemistry Division).

Standards for High Pressure Research. Oct. 14–18. Contact: C. W. Beckett (NBS Heat Division).

American Cybernetics Association. Oct. 24–25. Contact: Carl Hammer (UNIVAC).

Workshop on Mass Spectrometry. Nov. 18–19. Contact: A. J. Ahearn (NBS Analytical Chemistry Division).

SPECIAL PUBLICATION SERIES

The NBS Miscellaneous Publication Series has recently been redesignated the NBS Special Publication Series. Because this is merely a title change and not a new series, the numbering sequence will be retained.

The new title is more in keeping with the nature of the material appearing in the series, particularly the proceedings of the national and international meetings the Bureau sponsors. It also provides a more acceptable medium for material not suitable for other NBS publications.

1967 WEIGHTS AND MEASURES CONFERENCE

The publication, *52d National Conference on Weights and Measures 1967* [1] (218 pages, $1.25), is a report of the proceedings of that conference held June 26-30, 1967, in Washington, D.C. The Conference was designed to bring together weights and measures officials and representatives of business, industry, and trade associations.

NBS Spec. Publ. 297, edited by R. L. Koeser, contains the technical papers presented in the broad area of weights and measures. The contents also includes the reports of the Standing, Annual, and Executive Committees, and the Treasurer's Report, as well as the proceedings of the Seminar on Fair Packaging and Labeling.

[1] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

NATIONAL STANDARD REFERENCE DATA SYSTEM NSRDS NEWS

This column regularly reports significant developments in the program of the National Standard Reference Data System. The NSRDS was established in 1963 by the President's Office of Science and Technology to make critically evaluated data in the physical sciences available to science and technology on a national basis. The System is administered and coordinated by the National Bureau of Standards through the NBS Office of Standard Reference Data, located in the Administration Building at the NBS Gaithersburg Laboratories.

Physical Numbers

In the physical sciences, physical numbers are number pairs—the numerical value and its uncertainty. Indeed, all measured quantities (apart from defined values) are uncertain. The ability to interpret and assign an uncertainty to a number is one of the qualities by which a data evaluator is judged. In a sense, he is a detective searching for the number that follows the plus-or-minus sign.

Present day computers do not recognize these number pairs (physical numbers) as a matter of course. This is true even for computers that differentiate between integer, floating point, complex, and double-precision numbers.

Hopefully, those standard reference numbers that enter automated data banks will carry their uncertainties with them. As such data banks are expected to permit the user to calculate new quantities from the stored material, the results should be tagged with their uncertainties.

If these calculations using physical numbers are to be done in digital computers, the next generation of these machines should have the manipulative techniques built-in. The user should be able to handle physical numbers as easily as he can handle any class of numbers now recognized by computers. Since complex numbers are number pairs and are now handled automatically, the "pair" aspect of the problem is not novel. There are *no* aspects of the problem that are beyond the capabilities of the present scientific programming languages.

The mathematical operations needed to carry uncertainties through a calculation are contained in the set of operations provided in each language. However, the manipulations now must be done by programming and reprogramming. There seem to be no reasons why recognition and manipulation of these number pairs can not be built into compilers. A definition of a physical number handling system is given below in terms similar to those used for the manual operation, and one solution is described.

A computer system must:

(a) Be able to read a number on the input medium (cards, tape, or drum), and store both the number and its minimum uncertainty. (That is, 1.2, 0.012, and $12 \times 10^{13.0}$ all have the same uncertainty.)

(b) Permit the user to alter the uncertainty. (Often he will increase it, but he may wish to set it at a low value in order to study round-off errors.)

(c) Carry the uncertainties through a calculation. (The programs described below make use of the propagation of least square deviations through arithmetic operation.[1])

(d) Deliver to an output medium a number the length of which is consistent with its uncertainty, and upon demand, also deliver the uncertainty itself. (Several standard formats are desirable—just as they are for the printing of floating-point numbers.)

One solution to this problem has been developed by the NBS Chemical Kinetics Information Center. The need arose in the tabulation of rate coefficients. Over 1000 of these were available from several different sources. Different concentration, time, and energy units were used (moles per cubic centimeter, moles per liter, particles per cubic centimeter; seconds, minutes; and calories, calories per gas-constant, electron volts). The decision was made to tabulate all of them in logarithmic form, $\log_{10} k = A + B \log T - C/T$, listing the parameters A, B, and C consistent with concentrations in particles per cubic centimeter, time in seconds, and the energy term as the activation energy divided by the gas constant (E^*/R).

The complexity of the problem is demonstrated by the fact that some rate coefficients entered the system in the form,

$$k = (P \pm p) \times 10^{(N \pm n)} (T/300)^{(M \pm m)} \exp[(-E^* \pm e)/RT].$$

The simplest input procedure for a large-scale operation is to accept the coefficients in such an equation as they stand. Input is then a clerical operation; the machine can do the rest.

Programs were developed to handle the input and output physical number conversions. They were designed by C. L. Albright and R. J. Arms of the NBS Computer Services Division and coded in Fortran. (The programs are in UNIVAC Fortran V to run under the Exec II supervisor, but are readily convertible to Fortran IV). They will handle numbers for which uncertainties are not given as well as those for which they are. Input numbers are read (in a free field format) from fixed regions on the medium and converted to floating-point form. Output numbers and their uncertainties are delivered as Hollerith strings (either with an exponent or without) to the user's program, which then writes them.

The specification of the routine for propagation of the uncertainties has been left as an exercise for the user. The programs used at NBS have been successful in processing the thousand sets of rate parameters and in calculating rate coefficients at a standard temperature for intercomparison.

The programs are available to any who have need for them. They may not be ideal, but they exist. Hopefully, others who have faced this task will have different and better methods to suggest. The Chemical Kinetics Information Center is willing to organize an exchange of ideas on the subject.

A question now asked by data evaluators is, "When will the computer manufacturers relieve us of the problem?"

Advisory Panel on Raman Spectroscopy

Within the area of Atomic and Molecular Properties, NSRDS has been giving higher priority attention to the various topics of molecular spectroscopy. When the general Advisory Panel on Atomic and Molecular Data met in 1967 under the chairmanship of E. U. Condon, they recommended that an ad hoc panel of experts be convened to make a further study of Raman spectroscopy. The reason for the recommendation was the current revival of Raman spectroscopy employing laser sources for excitation.

Ellis R. Lippincott of the University of Maryland agreed to head the ad hoc panel, which was established as part of the NSRDS advisory structure administered for the Office of Standard Reference Data by the Office of Critical Tables of the National Academy of Sciences–National Research Council. The panel, which met on May 24, 1968, in Washington, D.C., consisted of E. R. Lippincott; E. D. Becker, National Institute of Arthritis and Metabolic Diseases; Harold J. Bernstein, National Research Council of Canada; James R. Durig, University of South Carolina; James E. Griffiths, Bell Telephone Laboratories; Ronald O. Kagel, The Dow Chemical Company; Peter J. Krueger, The University of Calgary; Dana W. Mayo, Bowdoin College; Foil A. Miller, University of Pittsburgh; S. S. Mitra, University of Rhode Island; James R. Scherer, U.S. Department of Agriculture; M. Kent Wilson, National Science Foundation; B. J. Zwolinski, Texas A&M University; E. L. Brady and S. A. Rossmassler, National Bureau of Standards; Mary E. Warga and J. A. Sanderson, Optical Society of America; Guy Waddington and H. van Olphen, Office of Critical Tables.

The panel agreed that early guidance for experimenters, authors, data compilers, and data users could be very valuable in promoting common understanding and full utilization of the body of information which is beginning to appear on this subject. They discussed guidelines for data measurement, data presentation, compilations, and international cooperation. They agreed to recommend a course of action for themselves and the National Standard Reference Data System to follow in the near future.

The panel plans to submit a report to the Office of Standard Reference Data with a statement of recommendations. It will also schedule meetings of small work-study groups, and will meet again in plenary session after these groups report.

COSATI Directory of Information Analysis Centers

The Committee on Scientific and Technical Information (COSATI) Panel No. 6 on Information Analysis Centers has issued a *Directory of Federally Supported Information Analysis Centers*. This publication should serve as a useful reference source for the identification of expertise in specialized fields.

The Directory is intentionally selective as inclusion was based on two specific qualifications: (1) The roster includes only those activities and programs operating within Federal Government agencies or being supported wholly or in part by Federal funds; (2) the roster includes only those activities which perform a majority of the functions within the scope of the Panel's definition of an information analysis center. The Panel's working definition of such a center was:

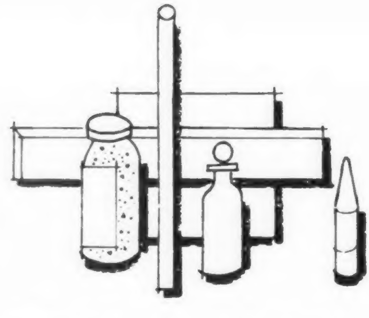
> An information analysis center is a formally structured organizational unit specifically (but not necessarily exclusively) established for the purpose of acquiring, selecting, storing, retrieving, evaluating, analyzing, and synthesizing a body of information and/or data in a clearly defined specialized field or pertaining to a specified mission with the intent of compiling, digesting, repackaging, or otherwise organizing and presenting pertinent information and/or data in a form most authoritative, timely, and useful to a society of peers and management.

One hundred-thirteen information analysis centers are listed in the Directory. Among information included for each entry are descriptions of mission, scope, services available, and user qualifications. For convenience, the Directory contains an index of subject areas covered, an index of names of center operators or directors, a list of organizations, and list of locations. In addition, the centers are numbered serially to facilitate indexing.

COSATI Panel 6 intends to keep the Directory cur-

continued on page 191

STANDARD REFERENCE MATERIALS



Gold Coating Thickness Standards [1]

NBS has recently prepared and certified two coating weight standards of gold on nickel. These standards, NBS Nos. 1376 and 1377, may be purchased separately or as a pair under the designation NBS No. 1385. The coating thickness standards are intended for calibrating coating thickness gages of the beta-backscatter type and for calibrating x-ray fluorescence methods for measurement of the thickness of gold coatings on nickel.

The specimens are 15 mm square and have nominal coating weights of 3 and 6 mg/cm^2, which are equivalent to 60 and 120 microinch thicknesses, respectively, for pure gold coatings having a density of 19.3 g/cm^3. The coating assays a minimum of 99.9 percent gold. It is electrodeposited either on an all-nickel substrate about 15 mils thick or on a 2 mil-thick nickel coating that has been electrodeposited on steel (AISI 1010). The nickel for either substrate is electrodeposited from a Watts nickel-plating solution and buffed prior to the gold plating. The certificate supplied with each standard gives the actual coating weight (and equivalent thickness) to within ± 5 percent of the actual weight per unit area at the center of the specimen.

The gold coating standards were measured by beta-ray backscatter and x-ray fluorescence techniques relative to NBS gold coating materials for which the average weights per unit area were determined by weight and area measurements. The beta-ray backscatter and x-ray fluorescence measurements were performed by J. Smit and M. McBee of the NBS Metallurgy Division. The standards are suitable for the direct calibration of equipment used to measure weight per unit area of gold coating of equivalent purity. From the density and weight per unit area, the instruments can be calibrated in terms of the thickness of the standard.

The coating thickness standards, Nos. 1376 or 1377, may be purchased singly for $43 each, or by the pair as No. 1385 for $68.[2]

Fluorine Microchemical Standard [1]

A new microchemical standard reference material, *o*-Fluorobenzoic Acid, has been prepared and certified for use in verifying the determination of fluorine in organic materials. The new standard, NBS No. 149, was purified at NBS and has a minimum purity of 99.7 mole percent.

The fluorine content was determined by decomposition using the oxygen-flask method, followed by potentiometric titration of the fluoride ion with lanthanum(III) using an ion-selective electrode as the fluoride sensor. Fluorine content of the standard averages 13.57 weight percent with a standard deviation of 0.07 percent from the mean of 14 determinations. The theoretical fluorine content of *o*-fluorobenzoic acid is 13.56 percent, the value recommended for NBS No. 149. This microchemical standard is sold in units weighing approximately 2 grams for $28, and a certificate of analysis is provided with each unit.[2]

Organo-fluorine compounds have come into widespread use fairly recently. Their fluorine contents are generally difficult to determine and standards are needed that are similar to the compound being analyzed. NBS No. 149 provides a relatively low-fluorine-content standard suitable for calibrating both automatic and manual microchemical apparatus and techniques. Preparation of a high-fluorine-content standard reference material is underway.

The *o*-fluorobenzoic acid was purified by C. L. Stanley of the NBS Office of Standard Reference Materials. Chemical analyses leading to certification were performed by R. A. Durst, R. A. Paulson, W. P. Schmidt, and R. F. Brady, Jr., all of the NBS Analytical Chemistry Division.

Standard Metallo-Organic Compounds [1]

The amount of wear on components of an internal combustion engine may be determined by analyzing its lubricating oil for metals. Such analysis is done with an optical emission spectrometer. Accurate predictions of wear or probable failure ordinarily are made on the basis of trends in data accumulated over a period of time from a series of determinations. To assure the accuracy of the analytical work, the spectrometer must be calibrated with standard reference materials.

The Bureau has developed a series of 24 different metallo-organic standards for this purpose at the request of the Division of Refining of the American Petroleum Institute. These standards are stable, oil-soluble to the concentrations needed, and do not absorb excessive

amounts of water. They yield solutions in lubricating oils which are constant and which do not precipitate on standing.[3]

Initially, the principal users of the metallo-organic standards were the railroad and trucking industries. The analysis for metals in lubricating oils was used as the basis for maintenance schedules and predictions of equipment failure. Agencies of the Department of Defense also utilize the metallo-organics for safeguarding equipment and for minimizing maintenance and repair costs. Newer uses include monitoring the presence of catalyst metals and catalyst poisons in process streams.

Three metallo-organic standards for determining metals in petroleum products were recently renewed and certified. They are: NBS Nos. 1057b, Dibutyltin bis(2-ethylhexanoate); 1069b, Sodium Cyclohexanebutyrate; and 1055b, Cobalt Cyclohexanebutyrate. These standards were prepared to fill the need for an adequate collection of standards which could be used to prepare a desired blend of known metal concentration in an appropriate lubricating oil.

These metallo-organic compounds were prepared by Distillation Products Industries, Rochester, N.Y. Chemical analyses were made by B. B. Bendigo and E. R. Deardorff; spectrochemical analyses by Virginia C. Stewart, all of the NBS Analytical Chemistry Division.

The standards are supplied in units of approximately 5 grams at a price of $26 per unit.[2] The certificate furnished with each standard gives the amount of the certified metallic element present, as well as directions for preparing a solution of known concentration in lubricating oil.

Surface Flammability Standard [1]

A renewal of the Surface Flammability Standard, designated NBS No. 1002b, has been issued as a material of prescribed flammability to provide an overall check of the installation and test procedures used with the radiant panel test apparatus (ASTM Standard Method of Test for Surface Flammability of Materials Using a Radiant Energy Heat Source, E-162). NBS No. 1002b is the second renewal of the surface flammability standard since it was initially offered seven years ago.

NBS No. 1002b has a flame-spread index of 210, and may be used for all applications for which its predecessor, NBS No. 1002a (now out of stock), was suitable. By comparing the results of the test with the listed properties of the standard, any deviation in the detailed test procedures can be evaluated. However, the standard is not recommended as a substitute for performing the prescribed calibration and standardization techniques.

The standard material is a representative sample from a uniform lot of tempered, fibrous-felted hardboard with one smooth side (the side measured). A certificate is supplied which lists the values of flame-spread index and heat evolution factor together with the measured coefficients of variation. Prior to calibration, the material must be dried for 24 hours at 160 °F and then conditioned to equilibrium at 73±5 °F and 50±5 percent relative humidity.

The radiant panel method of measuring surface flammability, previously developed at the Bureau, is a comparative method applicable to building materials—especially those used as interior finishes—over which flames of accidental fires could travel. These include materials in the form of boards, sheets, and certain heavy fabrics; and finish materials applied as liquids, films, or sheets, or combinations of these with or without intermediate adhesive substances.

The essential components of the test equipment are a radiant panel with its associated gas and air supply, a specimen holder and pilot burner, a stack and thermocouple assembly, a smoke sampling assembly, an exhaust hood, a radiation pyrometer, and associated recording equipment. The radiant panel, a section of porous refractory material, is mounted in a vertical plane and radiates energy at the same rate as a blackbody at 670 °C (1238 °F).

For checking the operational procedures, the standard material, backed with a sheet of asbestos mill board, is placed on a supporting frame inclined 30° to the vertical panel surface. A pilot flame of acetylene premixed with air ignites the specimen at the top. The progress of the flame front is followed by observing the times at which flames arrive at marked 3-inch intervals along the specimen length. The temperature rise of the stack thermocouples is a measure of the rate of heat evolution by the specimen.

These measurements are combined in an empirical relationship to provide a flame-spread index for the specimen. If the index resulting from a test of the surface flammability standard is within the specified limits of the certified value, it shows that appropriate apparatus installation and calibration procedures have been used.

A set of four specimens, 6 x 18 inches in dimensions, of the surface flammability standard, NBS No. 1002b, together with its accompanying certificate, are sold as a unit for $30.[2]

Engineering testing leading to the certification of NBS No. 1002b, Surface Flammability Standard, were performed by D. Gross and J. J. Loftus of the NBS Fire Research Section. Statistical analysis of the data was made by H. H. Ku of the NBS Statistical Engineering Section.

[1] For a complete list of Standard Reference Materials available from NBS, see **Standard Reference Materials: Catalog and Price List of Standard Materials Issued by the National Bureau of Standards**, NBS Misc. Publ. 260 (1968 ed.), for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 45 cents. Quarterly insert sheets which update Misc. Publ. 260 are supplied to users on request.

[2] These standards may be purchased for the price indicated from the Office of Standard Reference Materials, Rm. B308, Chemistry Bldg., National Bureau of Standards, Washington, D.C. 20234.

[3] **Analytical Standards for Trace Elements in Petroleum Products**, NBS Mono. 54 (1962). Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for 25 cents.

STANDARDS AND CALIBRATION

RADIOMETRIC CALIBRATION PROGRAM AND SERVICES EXPANDED

New Standards Developed

As part of a broad program aimed at the improvement of radiometric measurements, the NBS Institute for Basic Standards has recently developed new high-accuracy standards of spectral radiance, high-intensity standards of total irradiance, and instrumentation for accurately evaluating the quality of cavity radiators. The new standards and instrumentation now allow NBS to offer improved calibration services to Government agencies, research laboratories, aerospace firms, hospitals, and other users.

Previously existing radiometric standards included (1) standards of spectral radiance in the form of tungsten-ribbon-filament lamps developed by NBS in 1960; [1] (2) quartz-iodine lamp standards of spectral irradiance [2] (established in 1963); and (3) tungsten-filament lamp standards of total irradiance [3] which replaced the carbon-filament standards in 1966.

Although these standards have been used extensively in the calibration of radiometers, spectroradiometers, and other remote sensing devices, their use has been limited by such factors as the restricted wavelength range of calibrations, the relatively low intensities in the ultraviolet, and the calibration uncertainties associated with each of the standards. These limitations have been significantly reduced with the development of the new standards and calibration apparatus.

Spectral Radiance Standards

The new high-accuracy standards of spectral radiance are also tungsten-ribbon-filament lamps, but their calibration has been extended in wavelength and accuracy. Calibrations are now available from 850 nm to 210 nm with an uncertainty varying from about one to two percent in this range.

The new calibrations are performed on an apparatus incorporating a recently developed spectroradiometer, a 3000 K cavity radiator ("blackbody"), and a photoelectric pyrometer. The latter is capable of determining temperatures at 2500 K to an accuracy of about one kelvin.

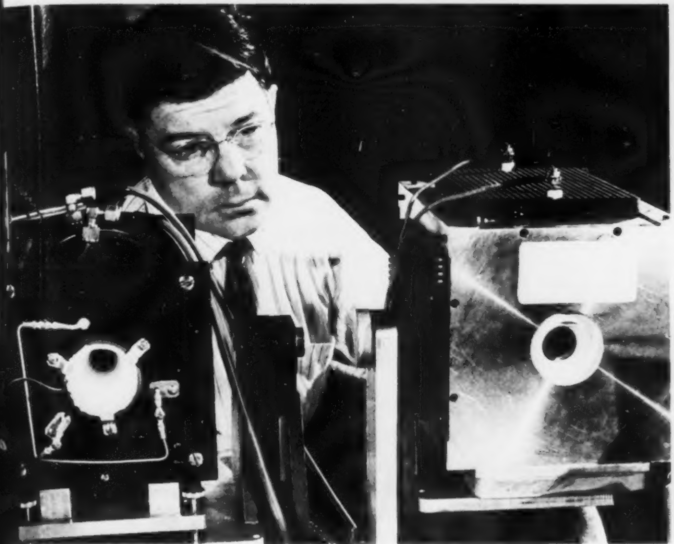
Total Irradiance Standards

Sources capable of producing total irradiances of the order of a solar constant (approximately $136\ \mathrm{mW\ cm^{-2}}$) have been developed by mounting 1000-watt tungsten halogen-type lamps in ceramic reflectors. The reflectors are slip-cast fused silica with flame-sprayed aluminum oxide reflecting surfaces. The lamp-reflector combination makes possible a source that is physically small (effective source size is 5 cm by 7 cm), but which emits relatively high, uniform irradiances. These high-intensity sources are calibrated for spectral as well as total irradiance.

J. K. Jackson alines a one-solar constant source that NBS recently developed as a high-intensity standard of total and spectral irradiance.

Infrared Blackbody Calibrations

Cavity radiators operating at temperatures between 500 K and 1200 K have been used extensively for radiometric calibration in the infrared. However, the extent to which the radiation from these cavities deviates from blackbody or Planckian radiation is not easily determined. Thus, a significant uncertainty often exists when using these radiators as calibration sources. The increased need for higher accuracy in infrared measurements has led NBS to develop instrumentation capable of calibrating these "blackbody" radiators.



C. R. Yokley positions a zinc-point and a variable-temperature blackbody in preparation for a spectral comparison.

The primary component of the NBS infrared calibration system is a "standard blackbody" operating below 1200 K, which has been carefully evaluated with respect to emissivity, temperature, and temperature uniformity. A specially designed spectroradiometer permits the radiance of a test blackbody to be compared to that of the standard blackbody at wavelengths from 1 to 4 μm. An extension to longer wavelengths is being planned. A preliminary estimate of the uncertainty of such spectral radiance calibrations, when not limited by the instability of the test cavity, is about one-half percent.

Other Programs and Services

Other NBS-radiometric programs that have already been initiated or are anticipated in the near future are the following: (1) The development of a high-pressure arc source having significantly higher ultraviolet radiance and irradiance than tungsten lamps, which will be used as a radiometric standard between 200 and 300 nm; (2) the improvement in accuracy and calibration to wavelengths below 250 nm of tungsten-halogen spectral irradiance standards; (3) the establishment of instrumentation and services capable of evaluating complete radiometric systems; and (4) the extension of the high-accuracy spectral radiance calibrations into the infrared (0.85 μm to 2.5 μm).

A complete listing of the radiometric calibration services is given in NBS Special Publication 250 (1968 Edition), *Calibration and Test Services of the National Bureau of Standards.*[4] Immediate or additional information pertaining to the above described standards, calibrations, or services may be obtained from:

W. E. Schneider
Rm. A223, Metrology Bldg.
National Bureau of Standards
Washington, D.C. 20234

TENTATIVE SCHEDULE OF 1968–69 NBS PRECISION MEASUREMENT SEMINARS

Details on First Seminar Announced

A tentative schedule of the 1968-1969 series of NBS Precision Measurement Seminars has been issued (see below). In addition, details have been released on the first seminar, which will deal with precision and accuracy in measurement and calibration. The seminars are conducted by members of the National Bureau of Standards and participation is open to persons from measurement and standards laboratories who meet appropriate prerequisites relating to education, work experience, and current professional activity.

Seminar on Precision and Accuracy

The first in the 1968-69 series of NBS Precision Measurement Seminars will be held October 7-9, 1968, on the campus of the West Coast University, Orange, California. Its subject will be: Precision and Accuracy in Measurement and Calibration. Members of the staff of the National Bureau of Standards will present the seminar under the auspices of the National Conference of Standards Laboratories (NCSL). The fee per person is $100.

Topics announced for the 3-day seminar are as follows: Measurement—qualitative and quantitative aspects. Errors, residuals, precision, accuracy. Quality control of a measurement process. Expression of the uncertainties affecting a measurement value. Propagation of error, recording of data, protection against outlying data. Experimental designs for calibration. Computer procedures.

Applicants must have undergraduate college training in engineering or physics and must be currently engaged at a professional level in metrology or calibration. Preparation for the seminar should include review of *ASTM*

continued

STANDARDS AND CALIBRATIONS *continued*

Manual on Quality Control of Materials, Special Publication 15-C; E. B. Wilson, *An Introduction to Scientific Research*, chapters 7, 8, and 9; Churchill Eisenhart, *Realistic Evaluation of the Precision and Accuracy of Instrument Calibration System, NBS Journal of Research* **67C**, pp. 161–187 (April–June 1963).

Laboratory directors who wish to have members of their staff attend are urged to send, as soon as possible, an "Application for Registration" to NCSL Secretariat, c/o National Bureau of Standards, Washington, D.C. 20234. Applications should be accompanied by a check to cover the fee, which is $100 per person, payable to National Conference of Standards Laboratories.

Acceptance of qualified applicants, whose number will be limited to 60, will be on a basis of first come first served, and will be made by letter no later than four weeks prior to the scheduled date of the seminar. (If there is sufficient interest, a second session will be held October 9–11, 1968, at the same place.) Detailed information on schedules and housing will be available at that time. Further details regarding seminar content, schedule, and lecturers may be obtained by contacting J. M. Cameron, Statistical Engineering Laboratory, National Bureau of Standards, Washington, D.C. 20234.

Tentative Schedule of Seminars

The following seminars and workshops conducted by NBS staff members and others are tentatively scheduled for presentation in the fall of 1968 and the spring of 1969. Laboratory managers wishing to send one or more of their people to any of these sessions are urged to write or phone the respective coordinator listed below to indicate the probable number of those expecting to attend. Seminars drawing insufficient interest will not be held.

Further details on specific seminars will appear later in the *Technical News Bulletin*. Suggestions for topics for discussion at future seminars may be sent to H. L. Mason, National Bureau of Standards, Washington, D.C. 20234. Telephone (301) 921–2806.

At the Gaithersburg facility, Washington, D.C. 20234:

- Low Frequency Electrical Standards, April 14–16 and April 28–30, 1969, R. F. Dziuba (301) 921–2727.
- Problems in Metrication, March 1969, A. G. McNish (301) 921–2658.
- High Voltage, 2 days, March 1969, F. R. Kotter (202) 362–4040, Ext. 7061.
- Gages, Tapes, Gears, 5 days, May 12–16, 1969, A. G. Strang (301) 921–2126.
- Lasers for Machine Shop Use, 2 days, May 1969, A. G. Strang (301) 921–2126.
- Thermometry, 0 to 1063 kelvins, 3 days, March 1969, H. H. Plumb (301) 921–2801.
- Mass and Weight, 2 days, May 1969, P. E. Pontius (301) 921–2511.
- Photometry, 4 days, May 1969, C. A. Douglas (301) 921–2761.

At the Boulder facility, Boulder, Colorado 80302:

- Laser Power and Energy Measurements, 3 days, March 1969, H. S. Boyne (303) 442–3455.
- Frequency and Time Stability, February 17–21, 1969, D. W. Allan (303) 442–3207.
- High Frequency Workshop, 5 days, April 1969, F. X. Ries (303) 442–3561.
- High Frequency and Microwave Power, 3 days, March 1969, P. A. Hudson (303) 442–3605.

At other locations:

West Coast University, Orange, California:

- Precision and Accuracy, October 7–9, 1968, J. M. Cameron, NBS, Washington, D.C. 20234 (301) 921–2315. (For details, see above.)

Open for choice of site:

- High Frequency and Microwave Impedance, 1 or 2 days January through April 1969, L. E. Huntley, NBS, Boulder, Colorado 80302 (303) 442–3574.

STANDARD FREQUENCY AND TIME BROADCASTS

WWV—2.5, 5.0, 10.0, 15.0, 20.0, and 25.0 MHz

WWVH—2.5, 5.0, 10.0, and 15.0 MHz

WWVB—60 kHz

Radio stations WWV (Fort Collins, Colo.) and WWVH (Maui, Hawaii) broadcast signals that are kept in close agreement with the UT2 scale by making step adjustments of 100 ms as necessary. Each pulse indicates that the earth has rotated approximately 15 arcseconds about its axis since the previous one. The pulses occur at intervals that are longer than one second by 300 parts in 10^{10} due to an offset in carrier frequency coordinated by the Bureau International de l'Heure (BIH), Paris, France. Adjustments are made at 0000 UT on the first day of a month. *There will be no adjustment made on September 1, 1968.*

Radio station WWVB (Fort Collins, Colo.) broadcasts seconds pulses derived from the NBS Time Standard (NBS-III) with no offset. Step adjustments of 200 ms are made at 0000 UT on the first day of a month when necessary. BIH announces when such adjustments should be made in the scale to maintain the seconds pulses within about 100 ms of UT2. *There will be no adjustment made on September 1, 1968.*

[1] Stair, R., Johnston, R. G., and Halback, E. W., J. Res. NBS **64A**, 291 (1960).

[2] Stair, R., Schneider, W. E., and Jackson, J. K., Appl. Opt. **2**, 1151 (1963).

[3] Stair, R., Schneider, W. E., and Fussell, W. B., Appl. Opt. **6**, 101 (1967).

[4] Calibration and Test Services of the National Bureau of Standards, NBS Spec. Publ. 250 (1968 Ed.), for sale by the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for $1.75.

NSRDS NEWS *continued*

rent through issuance of either supplemental information or revisions at appropriate intervals. Users are requested to send omission or revision information to COSATI Panel No. 6, c/o the Office of Standard Reference Data, National Bureau of Standards, Washington, D.C. 20234.

Copies of the Directory may be purchased from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151, for $3.

Critical Review of Hydrogenation of Ethylene on Metallic Catalysts

The catalyzed hydrogenation of ethylene in the presence of metallic catalysts, especially nickel, has been a subject of intensive investigations. The catalyzed hydrogenation was found to be associated with parahydrogen conversion, which turned out to be a useful profile of the reaction. In 1932 deuterium appeared as a powerful tool for revealing further profiles of the reaction. These profiles were traced in the early days by following the parahydrogen content as well as deuterium content in hydrogen by means of the thermal conductivity method. The deuterium content was at that time also determined by measuring the density of water to which the hydrogen of the samples in question was converted. Research work has been substantially facilitated since 1950 when infrared and mass spectrometers came into daily use for investigating adsorbed states and for determining deuterium content, including the relative amounts of different deuterium compounds.

NSRDS-NBS-13, *Hydrogenation of Ethylene on Metallic Catalysts* [2] (62 pages, $1), by Juro Horiuti and Koshiro Miyahara, critically reviews reaction rate data for the catalyzed hydrogenation of ethylene, primarily in the presence of unsupported metallic catalysts. Reaction mechanisms are discussed in detail, and a statistical mechanical treatment of the reaction is given, according to the generalized theory of reaction starting from the well-known procedure of Glasstone, Laidler, and Eyring. Data for single-element catalysts and alloys are included and interpreted, as are data illustrating differences due to the physical form of the catalyst (film, foil, wire, powder, and some supported systems). Problems are discussed concerning reproducibility of experimental results over repeated runs, and as a function of catalyst pretreatment. The data are analyzed in 29 graphs and 29 tables, some of which are very extensive. The bibliography includes 141 references.

Survey of Electrical Resistivity Measurements on 16 Pure Metals

NBS Technical Note 365, *Survey of Electrical Resistivity Measurements on 16 Pure Metals in the Temperature Range 0 to 273° K* [2] (111 pages, 60 cents), by L. A. Hall, should be of interest to workers and data center operators in solid-state physics. It compiles, tabulates, and graphically illustrates experimental data for aluminum, beryllium, cobalt, copper, gold, indium, iron, lead, magnesium, molybdenum, nickel, niobium, platinum, silver, tantalum, and tin. Each metal is treated in a section which contains the following items: (1) Sources of data; (2) additional references; (3) a discussion of factors influencing the character of the experimenter's resistivity data, such as purity, heat treatment, shape of sample, crystal structure; (4) tabulations of experimental data; (5) graphs plotted on logarithmic coordinates showing differences in values reported by several experimenters.

[1] Mandel, J., **The Statistical Analysis of Experimental Data**, p. 72 (John Wiley and Sons, Inc., New York, N.Y., 1964). Ku, H. H., J. Res. NBS **70C**, 263 (1966).

[2] Available from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402, for the price indicated.

PUBLICATIONS of the National Bureau of Standards*

PERIODICALS

Technical News Bulletin, Volume **52**, No. 7, July 1968, 15 cents. Annual subscription: Domestic, $1.50; foreign, $2.25. Available on a 1-, 2-, or 3-year subscription basis.

Journal of Research of the National Bureau of Standards

- *Section A. Physics and Chemistry*. Issued six times a year. Annual subscription: Domestic, $5; foreign, $6. Single copy, $1.
- *Section B. Mathematical Sciences*. Issued quarterly. Annual subscription: Domestic, $2.25; foreign, $2.75. Single copy, 75 cents.
- *Section C. Engineering and Instrumentation*. Issued quarterly. Annual subscription: Domestic, $2.75; foreign, $3.50. Single copy, 75 cents.

CURRENT ISSUES OF THE JOURNAL OF RESEARCH

J. Res. NBS **72C** (*Engr. and Instr.*), No. 3 (July–Sept. 1968), 75 cents.

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PUBLICATIONS *continued*

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**Publications for which a price is indicated are available by purchase from the Superintendent of Documents, U.S. Government Printing Office, Washington, D.C. 20402 (foreign postage, one-fourth additional). The NBS nonperiodical series are also available from the Clearinghouse for Federal Scientific and Technical Information, Springfield, Va. 22151. Reprints from outside journals and the* NBS Journal of Research *may often be obtained directly from the authors.*

CLEARINGHOUSE BIBLIOGRAPHIC JOURNALS**

U.S. Government Research & Development Reports. Semimonthly journal of abstracts of R&D reports on U.S. Government-sponsored projects and U.S. Government-sponsored translations of foreign technical material. Annual subscription (24 issues): Domestic, $30; foreign, $37.50. Single copy, $3.

U.S. Government Research & Development Reports Index (formerly *Government-Wide Index to Federal Research & Development Reports*). Semimonthly index to preceding; arranged by subject, personal author, corporate author, contract number, and accession/report number. Annual subscription (24 issues): Domestic, $22; foreign, $27.50. Single copy, $3.

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